3.2.2 Injection Flow.

7. (7) The minimum net fluid withdrawal to injection volume ratios and minimum inward hydraulic gradients at all observation well pairs will be determined empirically and based on testing and observation of aquifer response during initial ISR operations and may be adjusted as the wellfield development expands over time, in accordance with permit conditions and subject to EPA review and approval. Initial minimums can be set at one (1) percent for net withdrawals and 0.01 ft/ft for hydraulic gradients pending the evaluation of testing and observation at each well pair in correlation with the withdrawal versus injected volume.

Excelsior should amend and update the application accordingly.

Excelsior Response:

As discussed in response to comment 4, above, Excelsior proposes to initially pump the HC wells at a rate of one (1) percent of the injection rate and monitor the inward hydraulic gradient at observation wells adjacent to the HC wells. If excessive drawdown is observed at the HC wells such that the measured hydraulic gradient greatly exceeds 0.01 ft/ft, Excelsior will notify EPA and reduce the HC pumping so that the hydraulic gradient is closer to 0.01 ft/ft, minimum. Excessive, unnecessary drawdown is of concern for this particular mining operation because the oxide ore extends to and in some places above the groundwater table.

Section 3.2.2 of Attachment A-1 will be revised as shown in the response to #9.

8. (8) The proposed 30-day rolling average basis for operation of the wellfield and maintaining the balance of fluid injection with recovery well and hydraulic control volumes is acceptable with a demonstration that it is sufficiently protective of USDWs. Initially, the permit will require re-balancing on a 48-hour basis as discussed in greater detail in Comment 59 below until the applicant demonstrates that the 30-day rolling average re-balancing of volumes is as protective as re-balancing on a 48-hour basis during initial Stage 1 ISR operations. The intermediate monitoring and observation well data collected over a sufficient period of time may provide an adequate demonstration during start-up operations.

Excelsior should propose and submit an operational and monitoring plan for the demonstration and amend the application accordingly in this section and in Attachment H of the application.

Excelsior Response:

We are assuming the reference to "greater detail in Comment 59" should have referenced Comment 38. Excelsior agrees to record the pumping volumes for injection, recovery, and HC on a daily basis and rebalance on a 48-hour basis. These data will be evaluated at the end of 60 days of operations and assessed as to whether a n interval such as 30 days would be as protective. In addition to the flow rate data, Excelsior will consider water level and specific conductivity data collected from intermediate monitor wells.

Excelsior will submit an operational and monitoring plan to demonstrate that a 30-day rolling average is as protective as the 48-hour flow volume re-balancing. The plan would be a compliance schedule item. In addition, the UIC application will be amended along with Attachment H as noted in the response to comment 35. Also please see response to Comment 9 for proposed revision of Section 3.2.2 of Attachment A-1.

9. (9) Excelsior believes that a minimum gradient of 0.01 feet/foot (ft/ft) should be sufficient and measurable. As proposed, Excelsior should revise Section 3.2.2 of Attachment A- 1 in response to EPA's comments 7, 8, and 9 as presented in your prior response. The 30-day rolling average basis for operation of the wellfield will have to be demonstrated, as discussed above.

Excelsior should amend and update the application accordingly.

Excelsior Response:

Section 3.2.2 of Attachment A-1 will be revised as follows:

Injection Flow

Injection/recovery flows and hydraulic containment pumping will be actively managed to maintain an inward hydraulic gradient around the wellfield. The actual field conditions encountered during operation will determine the pumping and injection rates and the net pumping differential of the HC wells required to maintain an inward hydraulic gradient. Initially, Excelsior will pump the hydraulic control wells at a rate of 1% of the injection rate and monitor inward gradients at observation wells adjacent to the HC wells. The initial minimum hydraulic gradient will be set at 0.01 ft/ft. If excessive drawdown is observed at the HC wells such that the measured hydraulic gradient exceeds the minimum permitted hydraulic gradient, Excelsior will , with EPA concurrence, reduce the HC pumping so that the hydraulic gradient meets the permitted hydraulic gradient. ~~*Compliance with a specific net volume or net rate of extraction in excess of injection is not proposed as a permit condition, as it is expected to vary over time depending on the block(s) being mined and rinsed.*~~

Data acquired from hydraulic control and observation well data will be evaluated to determine permit limits for inward hydraulic gradients. T~~*o set permit limits for inward hydraulic gradients,*~~ *Excelsior proposes to calculate a minimum gradient for each well pair based on their separation distance and from testing and observation during the first two months of pumping at the associated hydraulic control well. Barometric pressure and earth tide differences at the site (1 to 2 feet) are significant relative to potentially small head differences at observation wells; therefore, it will be important to remove barometric and earth tide responses from water level data collected with pressure transducers. At this time, Excelsior believes a minimum gradient of 0.01 ft/ft will be sufficient and measureable, so two wells 100 feet apart should have a minimum head difference of 1 foot. Excelsior does not intend to use a pumping well to calculate hydraulic gradient, as well inefficiencies will exaggerate gradients. This methodology is conservative and defensible, while acknowledging the complex aquifer characteristics that have been identified and modeled.*

Initially, Excelsior proposes to operate the wellfield such that:

- *the total volume of injected fluids will not exceed the total volume of extraction from recovery wells and hydraulic control wells based on a 30-day rolling average;*
- *hydraulic control pumping will be 1% of injection pumping*
- *pumping volumes will be collected daily and re-balanced on a 48-hour basis so that the 1% net extraction is maintained.*
- *an inward hydraulic gradient will be maintained around the active portions of the in-situ wellfield, as measured in observation wells located near the hydraulic control wells (Figure A-7).*

After the first two months of operational data are available, they will be evaluated to determine appropriate permit limits regarding hydraulic gradients and net extraction rates.

Anticipated average and maximum injection volumes are provided in Attachment H.

3.2.4 Borehole Abandonment.

10. (10) Excelsior proposes plugging and abandonment of any wells or boreholes within an active mining block that are not suitably constructed to allow for monitoring or possible migration of injected solutions outside of the injection interval. Generally, the plugging and abandonment of wells and boreholes located within active mining blocks and the use of existing wells as intermediate monitoring wells around areas of injection should be adequately protection of USDWs. However, EPA considers the saturated portion of the basin fill and the underlying bedrock aquifer to be one aquifer and a USDW where not exempted, as discussed in Comment 2 above. EPA has concerns about the protection of the substantial USDW downgradient of the project area from migration of undetected contaminants through the basin fill or bedrock zones during ISR operations or rinsing and post-closure periods. EPA is not fully convinced that the bedrock ridge located just to the east of the wellfield would provide a permanent barrier to ISR fluids not captured by hydraulic control wells as implied in the response to this comment. However, intermediate monitoring wells and POC wells placed downgradient at the AOR perimeter should detect contaminants migrating to the east of ISR operations and trigger corrective actions to address an exceedance of water quality standards.

Excelsior should amend and update the application accordingly

Excelsior Response:

The bedrock ridge to the east of the wellfield is well documented based on drilling data. However, Excelsior did not state that it was a "barrier" to ISR fluids. Rather, it was stated that the ridge, which is composed primarily of carbonate rocks, would neutralize ISR solutions in the event that they were not captured by the hydraulic control wells. The neutralizing capacity of the bedrock was demonstrated in the geochemical model. There is no direct connection between saturated basin fill in the wellfield and the basin fill aquifer to the east of the site. In response to EPA's comment, the UIC application will be modified to reflect the presence and use of intermediate monitoring wells (in addition to the observation wells associated with hydraulic control wells that will be equipped with specific conductivity sensors). Excelsio r acknowledges EPA's concern regarding protection of downgradient USDWs and believes that the measures put forth in our meetings, discussions, and response to EPA comments will provide a high degree of early warning and, therefore, protection of all USDWs in the groundwater basin hosting the Gunnison project.

Section 3.2.1 of Attachment A-1 will be revised as noted in the response to Comment 5. Section 3.2.2 of Attachment A-2 will be revised as noted in the response to Comment 9. Excelsior believes these revisions should address EPA's concern.

3.2.6 Mechanical Integrity Testing.

11. (11) According to the prior response, Excelsior is willing to conduct Part 2 mechanical integrity testing and will revise the text as presented. However, the response is unclear if all wells would be tested for Part 2 mechanical integrity. If the saturated portion of the basal fill zone is included in the aquifer exemption, as discussed above, Part 1 mechanical integrity tests (MITs) in monitoring, observation, HC, and POC wells would not be required, unless converted to injection wells. Nevertheless, all wells should be pressure tested for casing leaks during construction or conversion to ensure that observation and monitoring wells provide data representative of the injection zone. HC well casings should be pressure tested to ensure that fluids are withdrawn from only the injection zone. See additional discussion and comments on MITs in the comments on Attachment P.

Excelsior should clarify that well casings in all wells will be pressure tested for leaks and Part 2 mechanical integrity testing will be conducted in all but the intermediate monitoring wells as described in Section 3.2.6. All injection and recovery wells require Part 1 MITs. Permit conditions will require that well construction records, including casing and cementing details, be provided for the proposed intermediate monitoring wells before EPA approval for conversion to monitoring wells. The application should be amended and updated accordingly.

Excelsior Response:

Excelsior will conduct Part 1 and Part 2 MI testing on all injection and recovery wells. For all other wells constructed by Excelsior (i.e. hydraulic control, observation, POC wells), a pressure test will be conducted to test the casing for leaks. However, this testing will not be conducted according to Part 1 MI protocols. Excelsior will submit all well construction records for the proposed intermediate monitoring wells as requested. The IMWs will be plugged and abandoned prior to injecting in the block in which they are located.

Section 3.2.6 of Attachment A-1 will be revised as follows:

> *Mechanical Integrity Testing*
>
> *Part 1 and Part 2 Mechanical Integrity Testing will be conducted on all new injection and recovery wells.*
>
> *After construction of an injection/recovery well is complete, Part 1 of the UIC mechanical integrity testing requirement will be addressed by the following method or another suitable method approved by ADEQ and EPA: A packer will be installed immediately above the bottom of the cased interval, and the casing will be completely filled with water. A hydraulic pressure equal to or above the maximum allowable wellhead injection pressure will be applied. The test will be conducted for a minimum of 30 minutes. The well will be considered to have passed if there is less than a five (5) percent loss of pressure during the 30 minute period. Part 1 mechanical*

integrity will be demonstrated before a Class III well is put into service and when there is reason to suspect a well failure.

If a packer completion is used (as shown in Attachment M), mechanical integrity testing of the tubing-casing annulus pressure will be conducted according to UIC requirements.

Part 2 mechanical integrity testing will be completed as part of the planned geophysical logging. As noted in Attachment I, Section 3.2, after injection/recovery well construction is complete, the well will be logged using the following borehole geophysical methods:

- *Gamma*
- *Sonic (injection wells only)*
- *Temperature (all wells)*
- *Caliper*
- *ABI (Acoustic Borehole Image)*
- *Cement bond logs (only on wells with steel casing) for Part 2 Mechanical Integrity.*
- *Directional survey*

The temperature logs will meet the Part 2 mechanical integrity requirement for wells constructed with PVC and/or FRP materials. The cement bond log will meet the Part 2 mechanical integrity requirement for wells with steel casing.

Because observation wells, POC wells, hydraulic control wells, and observation wells will not be used for injection, mechanical integrity testing conducted per Part 1 MIT protocols is not required, based on §146.8. However, a brief non-Part 1 MI pressure test will be conducted at each of these wells to test the casing for leaks.

Existing core holes or other existing borings/wells used for intermediate monitoring will not be tested. The IMWs will be plugged and abandoned prior to injecting in the block in which they are located.

Additional information regarding Mechanical Integrity testing is provided in Attachment P.

3.2.7 Rinsing.

12. (12) a) Please revise the last sentence on page 8 to read: "and all regulated constituents are at or below aquifer water quality standards (AWQSs) and UIC permit water quality standards. "UIC permit water quality standards will refer to primary maximum contaminant levels (MCLs), or pre-mining background concentration levels of regulated constituents, whichever is higher.

Excelsior should amend and update the application accordingly

Excelsior Response:

The requested change to page 8 will be made.

b) The permit may require that samples be collected from all recovery wells within each mining block after the third step and before approval of closure. As an alternative, the sampling requirement after the third step may be relaxed in subsequent mine blocks if it can be demonstrated that sampling 10 percent of the wells is statistically equivalent to sampling 100 percent of the wells in the rinsing of the initial mine block.

Excelsior should amend and update the application accordingly.

Excelsior Response:

Based on conversations with ADEQ and USEPA, Excelsior is proposing a new closure strategy. This strategy is provided in the response to Comment 15. It is proposed that Section 3.2.7 be revised as noted in the response to comment 15. Please also refer to the response to Comment 62.

b) Please revise the last sentence in paragraph 2 on page 9 to read: "Analysis will be conducted for APP and UIC permit regulated metals (dissolved), sulfate, TDS, pH, and specific conductivity."

The applicable UIC permit condition will be written to be consistent with the requested revision to paragraph 2 on page 9 and applicable water quality standards as stated above.

Excelsior should amend and update the application accordingly.

Excelsior Response:

The requested change to page 9, paragraph 2 will be made.

Section 4. Area of Review

4.3 AOR Delineation.

13. (14) The second paragraph states that the proposed western boundary of the AOR is coincident with the property boundary and is only 100 feet from the nearest injection wells. The eastward hydraulic gradient is expected to exceed the injection flows to the west, but the gradient and groundwater velocity values are not provided. Moreover, no hydraulic control or observation wells are proposed at the perimeter of the western AOR boundary and wellfield perimeter. If hydraulic containment were lost to the west, that loss would go undetected without HC and observation wells located at the western AOR boundary. The groundwater flow model results show containment at the western boundary, however, due to the heterogeneity and highly faulted structure of the orebody, this modeled outcome cannot be assured during actual ISR operations.

The use of intermediate monitoring wells, as described in the Excelsior PPT presentation of February 9th, addresses these concerns. Refer to Comment 5. Excelsior should identify the hydraulic parameters to be measured when the HC wells are installed and tested. Observation or monitoring wells should be installed at the western perimeter of the wellfield as discussed in the prior response and comments under Comment 5.

The application should be amended and updated accordingly.

Excelsior Response:

Excelsior will revise Section 3.2.1 of Attachment A-1 as described in the response to comment 5. The proposed intermediate monitor wells include two wells that are located along the western margin of the wellfield: NSH-16 and J-05. Excelsior believes these two wells combined with our regional understanding of groundwater flow and the fact that the Texas Canyon Quartz Monzonite dominates the geology to the west of the wellfield are sufficient to demonstrate a gradient to the east at the western boundary of the wellfield.

The hydraulic parameters that would be determined from aquifer testing of HC wells would include transmissivity, hydraulic conductivity, and storage coefficient. Section 4.3 of Attachment A-1 will be revised accordingly.

14. (16) Excelsior should clarify the hydraulic parameters noted in the prior response to comment 16 to be measured when the HC wells are installed and tested.

Excelsior Response:

The hydraulic parameters that would be determined from aquifer testing of HC wells would include transmissivity, hydraulic conductivity, and storage coefficient. Section 4.3 of Attachment A-1 will be revised accordingly.

15. (17) POC wells are to be placed at an appropriate distance to detect movement of regulated constituents during the proposed five-year post-closure monitoring period. Permit conditions may require additional POC wells to be placed at the AOR boundary or closer to the wellfield perimeter if recalibration of the groundwater flow model during ISR operations indicates a need for closer spacing of POC wells. Excelsior proposed the retention of 10 percent of the injection and recovery wells for post-rinse monitoring through the life of the mine, as presented in the February 9th PPT presentation. This would include monitoring a subset of retained wells annually for five years to verify no rebound has occurred.

Excelsior should clarify the rationale for the proposed POC well spacing at the eastern AOR boundary in response to our concerns about distance of the POC wells from the wellfield. The closure/post-closure strategy described in the February 9 PPT presentation should be added to the updated permit application. Monitoring frequency will be subject to EPA permit conditions and adjustment for monitoring results during rinsing and post-closure monitoring.

Excelsior Response:

The POC well locations were chosen based on Arizona Department of Environmental Quality's definition of POC. Under the Aquifer Protection Permit regulations, th e "Pollutant Management Area", which is coincident with the AOR of the UIC application, includes the barrier, i.e. the hydraulic divide caused by pumping of hydraulic control wells. The POC wells are required to be at the PMA boundary. Therefore, the POCs were placed based on this criterion. The spacing and number of wells is justified by considering the distance from the HC well system and the POC wells. As any excursion past the HC system migrates to the east, it will advectively disperse laterally through the aquifer allowing detection by widely spaced POC wells. Post closure excursions will first be detected at HC wells giving significant time to pull the excursion back using existing HC wells. The POC wells will provide backup confirmation that no mining solutions threaten downgradient aquifers.

Section 3.2.7 of Attachment A-1 will be revised to include the closure/post-closure strategy as follows:

3.2.7 Wellfield Closure Strategy

Closure of the wellfield will include rinsing to remove residual PLS and well abandonment, as discussed in the sections below. The closure strategy consists of the following elements:

- *Rinsing*
- *Well plugging and abandonment*
- *Report preparation*
- *Post-Closure Monitoring*

3.2.7.1 Rinsing Strategy

A rinsing closure strategy is proposed for the wellfield. After copper recoveries drop below the economic cutoff, ISR in a given production block will be deemed complete and the block will be rinsed using fresh groundwater until applicable water quality standards are met. A flow chart that summarizes the closure strategy is provided as Figure A-18.

Based on geochemical modeling by Duke HydroChem (Appendix J.1), the following 3-step rinsing strategy is proposed:

- *Rinse three (3) pore volumes (based on a 3% fracture porosity of the ore body)*
- *Rest*
- *Rinse two (2) pore volumes*

Step 1 will result in a mix of 5% PLS and 95% groundwater after rinsing with three pore volumes, based on core tray and column testing documented in a rinsing report by Clear Creek (Attachment H-2). The mechanism by which solute is removed during Step 1 is advective flow, i.e. flushing of the fractures.

Step 2 allows the solution to be neutralized as silicate and carbonate minerals are altered. Solute concentrations will be controlled by precipitation of secondary minerals and complexation (sorption) on hydrous ferric oxide surfaces. The resting period will continue until pH of the resident solution is circumneutral and all regulated constituents are at or below AWQSs or MCLs. The geochemical model results indicate that these conditions would be attained after a resting period of approximately one year (Attachment H-2).

Step 3 is a final rinse of two pore volumes. This step will facilitate removal of any constituents that might still be present at or near regulatory limits. Similar to Step 1, the solute removal mechanism of Step 3 is flushing.

To get to final closure, the following steps (which are also shown on the flow chart —figure A-18) will be taken:

- *Monitoring of groundwater from the mining block after rinsing will be conducted to evaluate the effectiveness of the rinsing. Samples will be collected from approximately 10% of the wells within the mining block after step 3, representing approximately 1 well for every 1.5 acres of the wellfield (figure A- 19). These wells (approximately 1 well per 1.5 acres) will be designated the "Rinse Verification Wells" (RVWs). The RVWs will remain open and available throughout the mine life to assist with closure verification and post rinse remediation if required. Analyses will be conducted for EPA [2] and*

---

[2] Those having primary MCLs.

APP-regulated metals (dissolved), sulfate, TDS, pH, VOCs[3] *and specific conductivity. Excelsior will select these wells based on their spatial, geological, hydrogeological, and geochemical representativeness. Only recovery wells will be sampled, as rinsed injection wells will not be representative of the bedrock groundwater chemistry. If analyses indicate that AWQSs or MCLs are not achieved in the block, rinsing and/or resting will resume.*

- *When AWQSs and MCLs are achieved in the RVWs, the remaining (non-RVW) wells in the mining block will be plugged and abandoned, leaving only the RVWs which represent approximately 1 well per 1.5 acres.*

- *An appropriate number (a subset) of RVWs will be selected as post-rinse IMWs. These wells will be selected to intersect major flow pathways while providing good geographic coverage. Their purpose is to identify possible migration of mining fluids from adjacent active mining areas back into previously-rinsed mining blocks. These IMWs will be continuously monitored for water elevation and specific conductivity. A post-rinse ambient specific conductivity level for the RVWs will be set as an AL that is indicative of compliance with AWQSs and MCLs, based on empirical data ("post-rinse AL") gathered during previous monitoring.*

- *In the event of increasing specific conductivity above the ALs in the IMWs, Excelsior will implement the following response(s):*

  - *Continued monitoring to establish neutralization capacity and/or*

  - *Adjust operations to reverse the trend (pull back solutions) and/or*

  - *Adjust nearby rinsing operations to reverse the trend*

- *When an area is to be closed because it is the end of the mine life or there is no future mining planned adjacent or up-gradient, a subset of the RVWs will be identified (approximately 1 well every 13.5 acres as shown on Figure A-19). These wells will be designated as "Closure Verification Wells" or CVWs. Samples from these wells will be analyzed by laboratory methods for APP-regulated metals (dissolved), sulfate, TDS, pH, VOCs and specific conductivity. When all CVWs in an area meet AWQS or MCLs then applicable hydraulic control wells will be turned off (but not abandoned).*

- *To determine if later rebound above AWQS or MCLs has occurred, monitoring of CVWs will continue once per year until 5 consecutive years of CVWs meeting AWQSs and MCLs has occurred. If in any year AWQSs or MCLs are not met in a particular area, appropriate HC wells can be turned back on and additional pumping, rinsing or resting of CVWs and/or adjacent RVWs can occur.*

---

[3] Excelsior proposes to use the full EPA 8260B analyte list for VOC analyses, as listed in the EPA Method.

- *When all CVWs have met AWQSs and MCLs for five consecutive years, monitoring will stop and all wells (RVWs, CVWs, HC, Observation and POC) will be plugged and abandoned.*

Prior to well plugging and abandonment of a mining block, a report will be submitted to ADEQ and USEPA documenting the rinsing and monitoring data. The report will include documentation of the volumes of rinse water injected and recovered, results of laboratory analytical analyses after Step 3, and a recommendation will be provided on whether additional rinsing is needed. Well plugging and abandonment will not commence without approval from ADEQ and USEPA. As discussed above, approximately 1 well every 1.5 acres will be designated as Rise Verification Wells (RVWs), a subset of which will become either post-rinse IMWs or later Closure Verification Wells (CVWs) and will not be abandoned until the end of the life of mine, to allow for monitoring as described above.

Well rinsing costs for Stage 1 operations are provided in revised Attachment R-3 in the response to comment 61.

3.2.7.2 Well Plugging and Abandonment

After the goals of the rinsing are met, the wells in the wellfield, which are classified as Class III injection wells under the UIC regulations, will be plugged and abandoned, as required under 40 CFR 146.10. This requires that wells be abandoned in such a way that fluid will not move into USDWs. In addition to the federal requirements, AAC R12- 15-816 contains abandonment requirements and additional guidance is provided in the ADWR Well Abandonment Handbook (ADWR, 2008). The handbook states that the abandonment of a well be accomplished "through filling or sealing the well so as to prevent the well, including the annular outside casing, from being a channel allowing the vertical movement of water."

Class III Well plugging and Abandonment procedures will be similar to those described in Section 7.1.4.3.

Following the plugging and abandonment of Class III injection/recovery wells, reports will be filed with state and federal agencies as described below.

- *<u>ADWR:</u> Within 30 days of the completion of plugging and abandonment the drilling contractor will submit a Well Abandonment Completion Report (Form 55-58) to ADWR. Within 30 days of completion of plugging and abandonment Excelsior or their designee will submit a Well Owner's Notification of Abandonment (Form 55 -36). The forms are included as Exhibit B.*

- *<u>USEPA:</u> Excelsior will report plugging and abandonment activities in the quarterly monitoring reports sent to the USEPA Director. The plugging and abandonment will be included in the quarterly report for the quarter in which the activities were completed.*

Reporting data will include an updated version of Form 7520-14 and copies of the forms sent to ADWR described above.

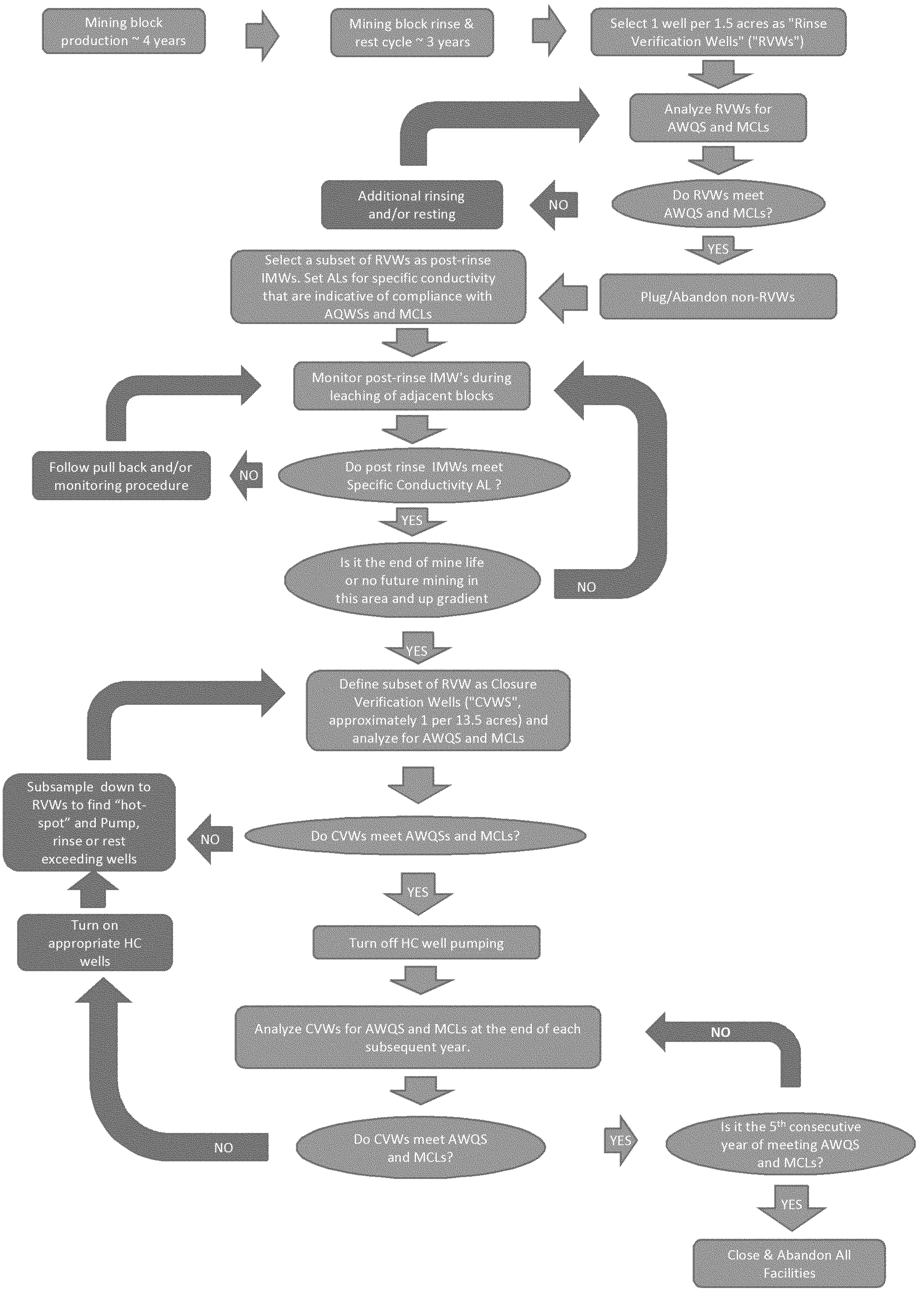
- *ADEQ: Will receive copies of all documentation of plugging and abandonment activities that are sent to ADWR and USEPA.*

3.2.7.3 Post-Closure Groundwater Monitoring

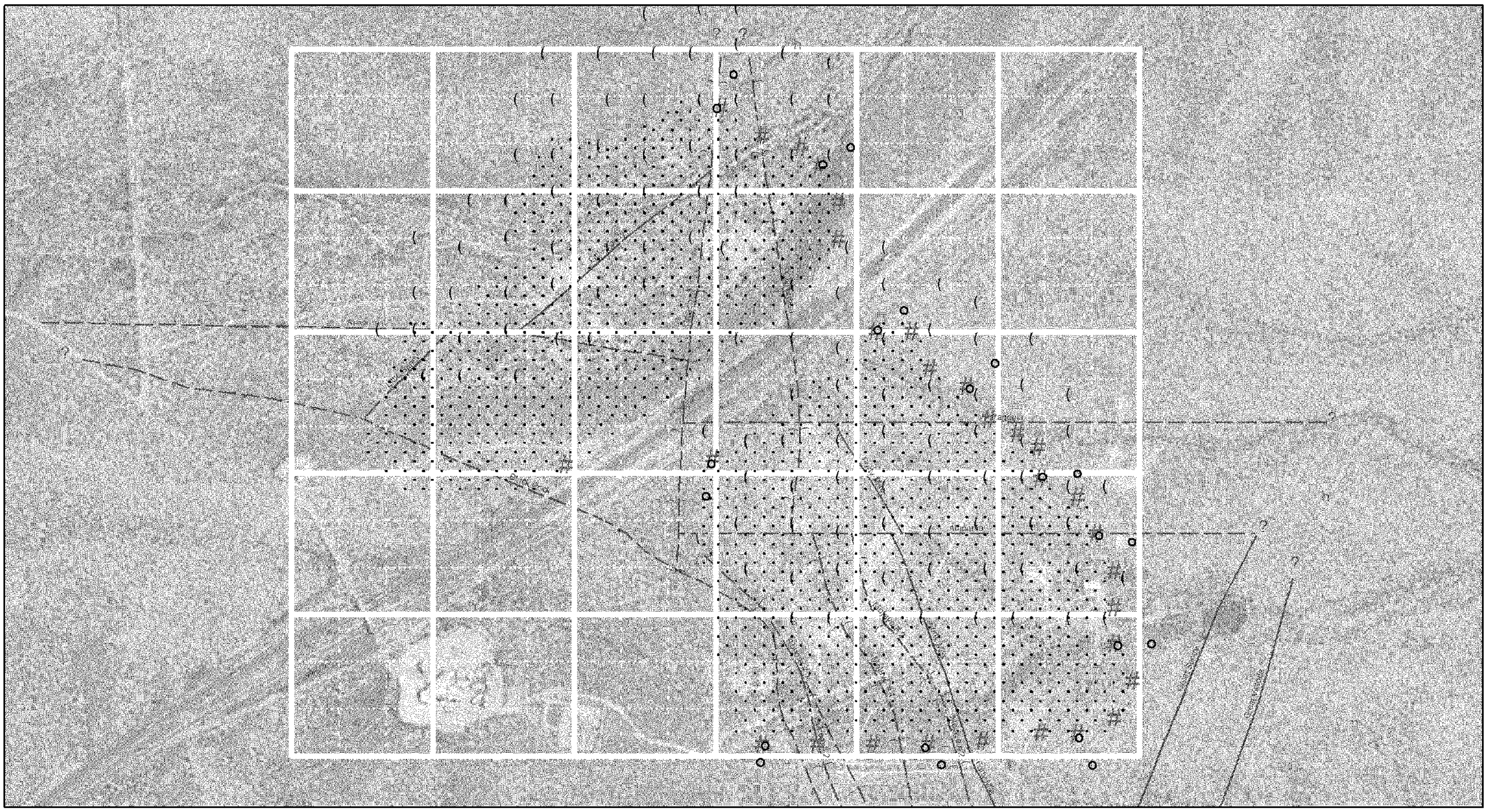
Geochemical modeling (Appendix J.1 and Section 7.1.5.1) has shown that AWQSs will be achieved after rinsing. Post closure monitoring will be conducted as summarized in the Section 7.1.5.1. Because Excelsior intends to rinse until MCLs and AWQSs are achieved within the wellfield, monitoring at the POCs will not be conducted. Rather, post-closure monitoring will be conducted the selected CVWs within the wellfield for 5 years. The samples will be collected annually, according to the methodology prescribed in the permit.

Excelsior has proposed that when AWQS and MCLs are achieved for five (5) successive years, post closure monitoring can be terminated and the remaining wells (monitoring, hydraulic control, POC) can be abandoned.

FIGURE A-18: Closure Strategy Decision Tree



ED_001697_00000744-00016



HC Observation Wells	RVW
Wellfield POC Wells	CVW
HC Well	13.5 acres
Production Well	1.5 acres
	Wellfield Boundary

1,000 500 0 1,000 Feet

Excelsior MINING CORP

Excelsior Mining Arizona Inc.
Gunnison Copper Project
Date Revised: 2/21/2017

Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet

FIGURE A-19 **CLOSURE AND POST-CLOSURE MONITORING LOCATIONS**

Attachment A-2, Groundwater Modeling Report

Groundwater Model

2.5.1 Aquifer Systems.

16. (20) Refer to Comment 2. EPA believes there is sufficient evidence to include the basin fill saturated zones as hydraulically connected to and part of the bedrock aquifer, and that it should be included within the aquifer exemption as presented in the Excelsior response.

Excelsior should amend and update the application as presented in their response.

Excelsior Response:

Excelsior agrees to apply for exemption for the saturated portion of the basin fill aquifer within the AOR. Excelsior proposes that the top of the exemption zone proposed in the UIC application be changed so that basin fill below 4185 feet in elevation will be included in the aquifer exemption. This elevation is based on groundwater levels in NSH-006 and NSD-020, which are the only two wells screened solely in the basin fill, and which have saturated alluvium

Excelsior will amend the UIC application to reflect this change.

2.5.2 Groundwater Movement and Boundary Conditions.

17. (22) The application indicated that the recharge calculations are based on the assumption that approximately 3% of available precipitation recharges the aquifer, with the assumption based on information from other similar modeling studies. No references to those other modeling studies were provided in the application.

Excelsior should update the application as presented in the prior response with the citations to (or copies of) those modeling studies that were the basis of the assumptions used in the recharge calculations.

Excelsior Response:

The requested citations will be included in the updated UIC applications. They include:

Robson, S. G. and Banta, E. R., 1995, Ground water Atlas of the United States; Arizona, Colorado, New Mexico, Utah; USGS HA 730-C

Blasch, et al, 2005, Hydrogeology of the Upper and Middle Verde River Watersheds, Central Arizona; USGS Scientific Investigations Report 2005-5198; Table 23.

Pool, D.R., Blasch, K.W., Callegary, J.B., Leake, S.A., and Graser, L.F., 2011, Regional groundwater-flow model of the Redwall-Muav, Coconino, and alluvial basin aquifer systems of northern and central Arizona: U.S. Geological Survey Scientific Investigations Report 2010-5180, v. 1.1, 101 p.

Because these documents are quite large, it is impractical to include them in the UIC Application. The references will include web links to the documents if they are available.

4.4 Hydraulic parameters.

4.4.1 Hydraulic Conductivity

18. (26) The vertical hydraulic conductivity values used in the model should be re-calibrated to ISR operations performance as operational data are collected and evaluated in the initial stage. Refer to Comment 1.

Excelsior Response:

As noted in the response to comment 1, Excelsior will be incorporating operational and testing data to the groundwater computer model after the first year of operations and periodically during the life of the mine. Verbiage from the response to Comment 1 will be added to Attachment A-2 of the UIC permit application to describe the periodic update of the model and what data will be incorporated.

4.4.2 Storage values.

19. (27) The range of porosity values for the sensitivity analyses in the model predictions should also reflect the distribution of the porosity values in the formation. The 50% reduction in porosity might not be sufficient to incorporate the expected porosity values in the site. Furthermore, Figures 42A and 42C in the prior response document show there is a slight excursion of the particles out of the boundary in the south and west sections of the wellfield which coincides with the AOR boundary. If a combination of conditions is selected that would result in the potential loss of hydraulic control (hydraulic conductivity values in the fault zone and other zones of the model and porosity values), it is possible that this excursion could extend further outside the AOR. Therefore, additional monitoring wells should be placed to the west of the wellfield for detection of loss of containment in or excursions from the AOR. Later during ISR operations, if monitoring and observation well data indicate a loss of hydraulic containment or excursion of ISR fluids beyond the proposed AOR, the AOR could be expanded at the southern and western boundary. The proposed intermediate monitoring wells discussed in the conference calls with Excelsior should provide protection from excursions to the south and west of the wellfield.

Excelsior should amend and update the application in Section 4.9.1 as presented in the response to sensitivity analysis for porosity variations and the above discussion.

Excelsior Response:

Excelsior estimated porosity using gamma-gamma density logging as described in Section 4.3.3.4 of Attachment A-2 of the UIC application. The range of porosity from seven boreholes logged was 1.3 to 5.7 percent. Using the assumed 3.0 percent, 50 percent of 3.0 percent is 1.5 percent, roughly a value equivalent to the low end of the measured range. The possible values for porosity cannot be significantly lower than these numbers, based upon observed conditions at the site. Excelsior believes that based on the measured range, 50 percent is appropriate for sensitivity testing.

As discussed in response to comment 13, the proposed IMW monitoring network locations includes two wells along the western boundary that are well located to detect gradients to the west if they should develop and/or excursions of mining solutions to the west. IMWs to the south of Stage 1 operations will provide an early warning system for the southern boundary of the AOR. (Locations of Stage 1 IMWs are provided in Figure A-8 which is provided with the response to Comment 5).

It should be noted that the “slight excursions” to the west of the wellfield are not excursions. These are particles that started west of the wellfield at the center of the cell and moved into the wellfield. There is a steep eastward gradient to the west of the wellfield, and there are no excursions to the west.

Section 4.9.1 of the UIC application will be amended as follows:

4.9.1 Hydraulic Control Sensitivity

One of the concerns regarding the groundwater model is whether the hydraulic control scheme can be maintained if unforeseen conditions that accelerate fluid movement are present. To evaluate this possibility, the hydraulic capture model was modified to test: 1) higher hydraulic conductivity in fault zones, and 2) lower porosity. These conditions would represent the most likely scenarios where the potential for loss of hydraulic control could be identified.

As discussed, the hydraulic conductivity was set based upon the fracture intensity. Faulted zones have high hydraulic conductivity, and represent the most logical possible route for preferential flow. To test this, the model hydraulic conductivity zones representing FI of 4 (K = 10 ft/d) were reset to 50 ft/d. This is approximately equivalent to the hydraulic conductivity for an FI value of 5 (65 ft/d). Figure 42A illustrates the results of this simulation, indicating that hydraulic control was not lost.

In order to assess the sensitivity of the modeled capture to changes in porosity, two simulations were conducted using porosity lowered by 20 percent (%) and 50%. These values were chosen because the possible values for porosity cannot be significantly lower than these numbers, based upon observed conditions at the site. Lower porosity would increase the speed of particles, which may allow for excursions out of the wellfield area. Figure 42B illustrates the results of the simulation with porosity reduced by 20%. Because specific yield was based upon porosity (80% of porosity), the specific yield was also reduced by 20%. The particle tracking indicates that capture was maintained.

Figure 42C illustrates a 50% reduction in porosity and specific yield. A review of these results indicates that capture was also maintained in this scenario. Based on these results, the estimate of hydraulic containment is viable for overall porosity of 50% of simulated values.

Explanation

D Hydraulic Control Wells

Higher Hydraulic Conductivity
Model Layer

3
4
5
6

Wellfield

0 250 500 1,000
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
December 2016

Date	File ID
12/08/16	373002

CLEAR CREEK ASSOCIATES

FIGURE 42A
Particle Tracking: Years 1-23
Increased Hydraulic Conducivity
Zones where FI=4

Explanation

D Hydraulic Control Wells

80% Porosity Simulation
Model Layer

- 3
- 4
- 5
- 6

Wellfield

0 250 500 1,000
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
December 2016

Date	File ID
12/08/16	373002

CLEAR CREEK ASSOCIATES

FIGURE 42B
Particle Tracking: Years 1-23
Porosity and Specific Yield
Reduced by 20 Percent

ED_001697_00000744-00025

Model Predictions

5.1 Hydraulic Control Simulation.

20. (32) The simulated time for particles to reach the POC wells 2, 3, 4, and 5 at the AOR boundary is exceeds 20 years. If an excursion occurs beyond the wellfield to the east and north in the post-rinsing period of five years, it would not be detected at the POC wells. Excelsior indicated that the HC and observation wells would be retained during the five-year post-rinsing period during conference call discussion on February 9th. If the HC and observation wells at the boundary of the wellfield are retained for post-rinsing monitoring, excursions could be detected within the five-year post rinsing window and reversed.

Figure 64 should be revised to show the AOR boundary. Excelsior should clarify and add the commitment to retain the HC and observation wells during the post-rinsing period and propose a monitoring plan and schedule for the observation wells. The related conference call discussions should be documented in the updated permit application.

Excelsior Response:

As requested, Excelsior has revised Figure 64 (attached) to show the AOR. ADEQ has also requested that Figure 64 be revised with regard to the calculation of the Discharge Impact Area.

Excelsior has proposed a new closure and post-closure monitoring strategy, which is provided in the response to comment 15. We believe this new strategy addresses EPA's concerns regarding possible excursions beyond the wellfield in the post-rinsing period, as it includes rinse verification wells and closure verification wells *within the wellfield*. Please refer to the response to comment 15. HC and observation wells will be retained until the end of the project, and will be available for monitoring at any stage of the Project.

FIGURE 64
Discharge Impact Area
23 Year Simulation

5.1.2 Hydraulic Control Wells.

21. (33) The proposed intermediate monitoring wells should detect excursions from active mining areas that the modeling fails to predict and the limited number of HC or observation wells fail to detect in the early years of ISR operations, which reduces the need for full activation of 19 HC and observation wells in the early years. *Activation of site-specific HC wells should be dependent on intermediate monitoring well data.*

Excelsior Response:

In response to this comment, Section 5.1.2 of Attachment A-2 will be revised as follows:

> *Hydraulic Control Wells*
>
> *The active blocks are shown on Figure 45, which shows the progression of active mining from 1 to 23 years. The groundwater model was set up with a steady state starting period, and then 23 one year stress periods, each broken into 2-month time steps. The model used particle tracking to evaluate containment. Because the project is a balanced injection and recovery system, containment of the fluids is achieved through a pumping containment system, with hydraulic control wells placed at the periphery of the AOC. These wells were initially sited at a spacing of approximately 300 feet apart, but well spacing was adjusted or wells were added in zones of high hydraulic conductivity to maintain containment as indicated by particle capture. Figure 46 illustrates location of the 30 wells simulated for the containment system.*
>
> *As described in Attachment A-1, during operation of the wellfield, the IMW network will be used to detect excursions from active mine blocks. The IMW system includes an inner and an outer ring of monitoring wells that expand as mining operations expand. IMW's will be monitored for specific conductance and water elevation.*
>
> *The inner ring is primarily for operational use, allowing operators to observe the immediate effects of changes in operational conditions like injection or recovery rates. Some mining solutions are expected to be observed in these wells due to the sweep of solutions in and out of the margins of the active mining blocks. This is considered normal.*
>
> *The outer ring is designed as an early warning system to ensure the appropriate hydraulic control wells are installed and operating. Appropriate alert levels for specific conductivity will be set in the outer ring of IMW's. Increasing trends above alert levels in o uter wells would illicit the following response(s):*
>
> - *Adjust operations to reverse the trend (pull back solutions) and/or*
> - *Install interceptor HC wells (if not already installed)*
> - *Adjust pumping in HC wells if needed*

5.1.3 Particle Tracking.

22. (34) The application indicated that because of the slow movement of particles across the mining area, particles are first released six years after mining starts. Due to faulting and fracturing in site geology, it is possible that ISR fluid could move faster through fractures (secondary permeability features) in some parts of the site.

Excelsior should amend and update the application in Section 5.1.3 as presented in your justification for particle release time given possible fracture flow in places in the prior response to this comment.

Excelsior Response:

The particle tracking analysis has been modified to allow release of particles on an annual basis through Stage 1 of mining. This will provide a more detailed analysis of travel directions and velocities for each mining block of Stage 1. The UIC application will be revised to reflect the results of the new particle tracking analysis.

Section 5.1.3 will be replaced with the following paragraphs:

5.1.3 Particle Tracking

> *To evaluate the capture of particles over the period of mining/rinsing, a particle tracking simulation was constructed. Particles were placed around each active group of mining blocks at the end of each year. Figure 47 illustrates an example of the placement of particles for mining year 5, where blocks for years 2-5 were either being actively mined or rinsed. Particles were placed for each mining year until the end of the simulation, and the simulation was run until active mining ends. Particles were placed in Model Layers 3, 4 and 5 which represents the area of active mining.*
>
> *The groundwater model and particle tracking simulation are based upon an equivalent porous media (EPM) assumption about the nature of the hydraulic conditions at the site. Due to the degree of fracturing and interconnectedness of the system as demonstrated by the aquifer testing, this is a reasonable assumption. Because the model simulates the interconnected high conductivity fracture zones as a series of connected higher conductivity model cells, the simulation of the potential fracture conduits has been addressed. Additional sensitivity testing of lower porosity (higher flow velocity simulations) has also addressed this concern, evaluating the control scheme under higher velocity of flow conditions.*

Explanation

Hydraulic Control Wells
Pumping in Year 5

- D Active this Period
- P Not Active this Period
- Particle starting points after 5 Years
- Year 2
- Year 3
- Year 4
- Year 5
- Wellfield

0 250 500
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
November 2016

Date	File ID
11/22/16	373002

CLEAR CREEK ASSOCIATES

FIGURE 47
Particle Starting Location
for Mining Year 5

5.2.2 Capture Analysis.

23. (35) Figures 57, 58, and 59 in Attachment A-2 of the application show some particles leaving the wellfield area and possibly leaving the AOR on the west side of the site. Due to uncertainties, additional monitoring wells should be placed to the west of the wellfield for detection of possible excursions or loss of containment in the AOR. Excelsior proposed the addition of intermediate and other monitoring wells west of the active mining blocks during the February 9th conference call with EPA with PP T illustrations of the well locations in the wellfield.

Excelsior should document those proposals and illustrations in the updated permit application.

Excelsior Response:

The particles shown on the referenced figures actually START outside the wellfield, at the center of a model block, and move into the wellfield. This is simply a relic of the model construction where some blocks straddle the wellfield boundary. Particles were started at the centers of blocks. If the center of the block was outside the wellfield boundary, it appears as though there are excursions from the wellfield. These figures will be revised to remove particles starting outside the wellfield. These figures DO show that particles quickly move into the wellfield, due to the steep west to east hydraulic gradient. Excelsior has revised the drawings (as attached) so that no particles start outside the wellfield.

Intermediate monitor wells will be located on the western boundary of the well field and are adequately located to detect hydraulic gradients to the west if they should develop and/or excursions of mining solutions. See responses to comments 5, 13 and 21.

Explanation

Particle Tracks for Layer 3

YEAR

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 18
- 19 - 21
- 22 - 23

Hydraulic Control Wells

Wellfield

Township

Particles started outside the wellfield area to the west were deleted until they entered the area of the wellfield.

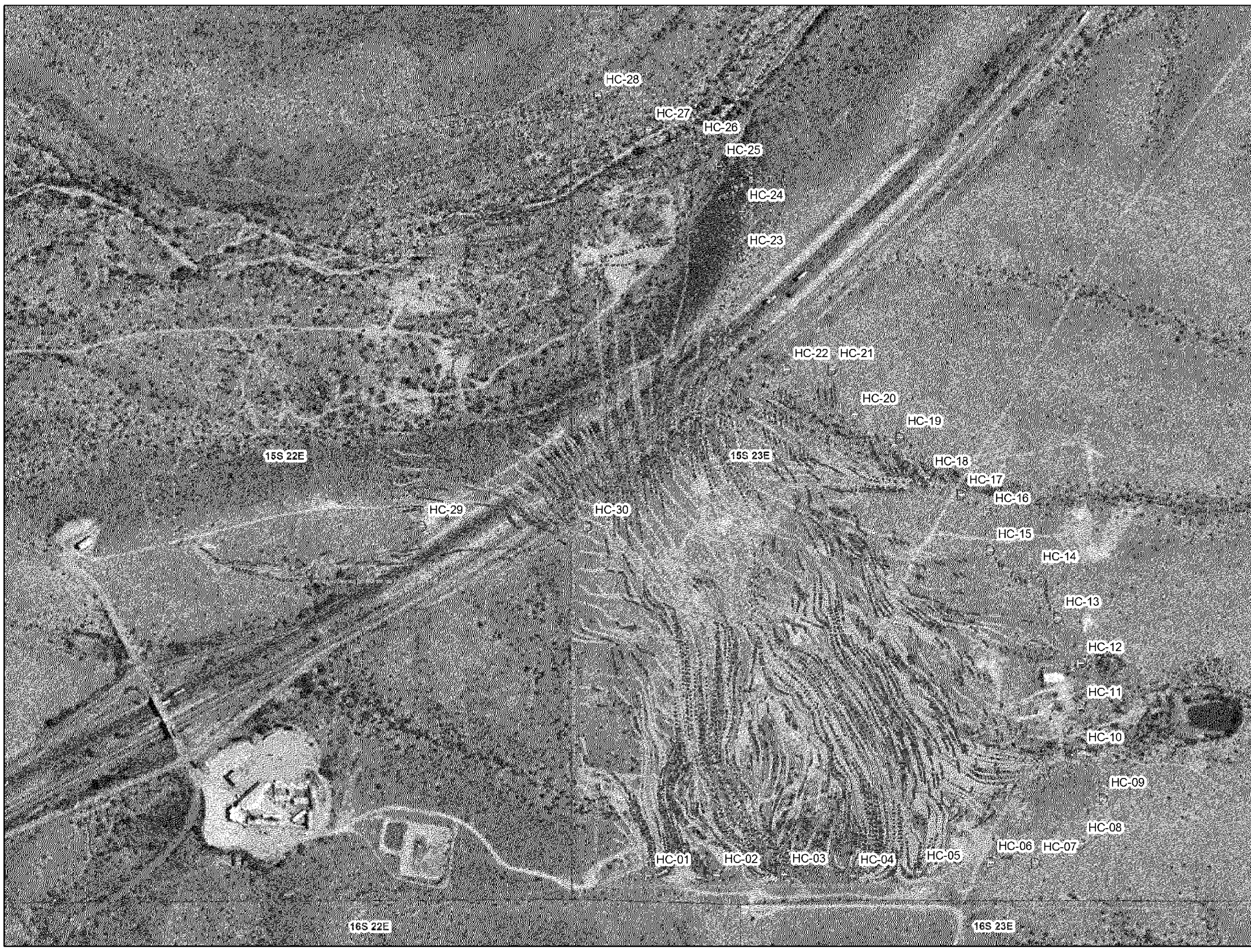
0 200 400 800
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
March 2017

Date	File ID
3/20/17	373002

CLEAR CREEK ASSOCIATES

FIGURE 57
Updated Particle Tracks
for Layer 3



Explanation

Particle Tracks for Layer 4

YEAR

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 18
- 19 - 21
- 22 - 23

Hydraulic Control Wells

Wellfield

Township

Particles started outside the wellfield area to the west were deleted until they entered the area of the wellfield.

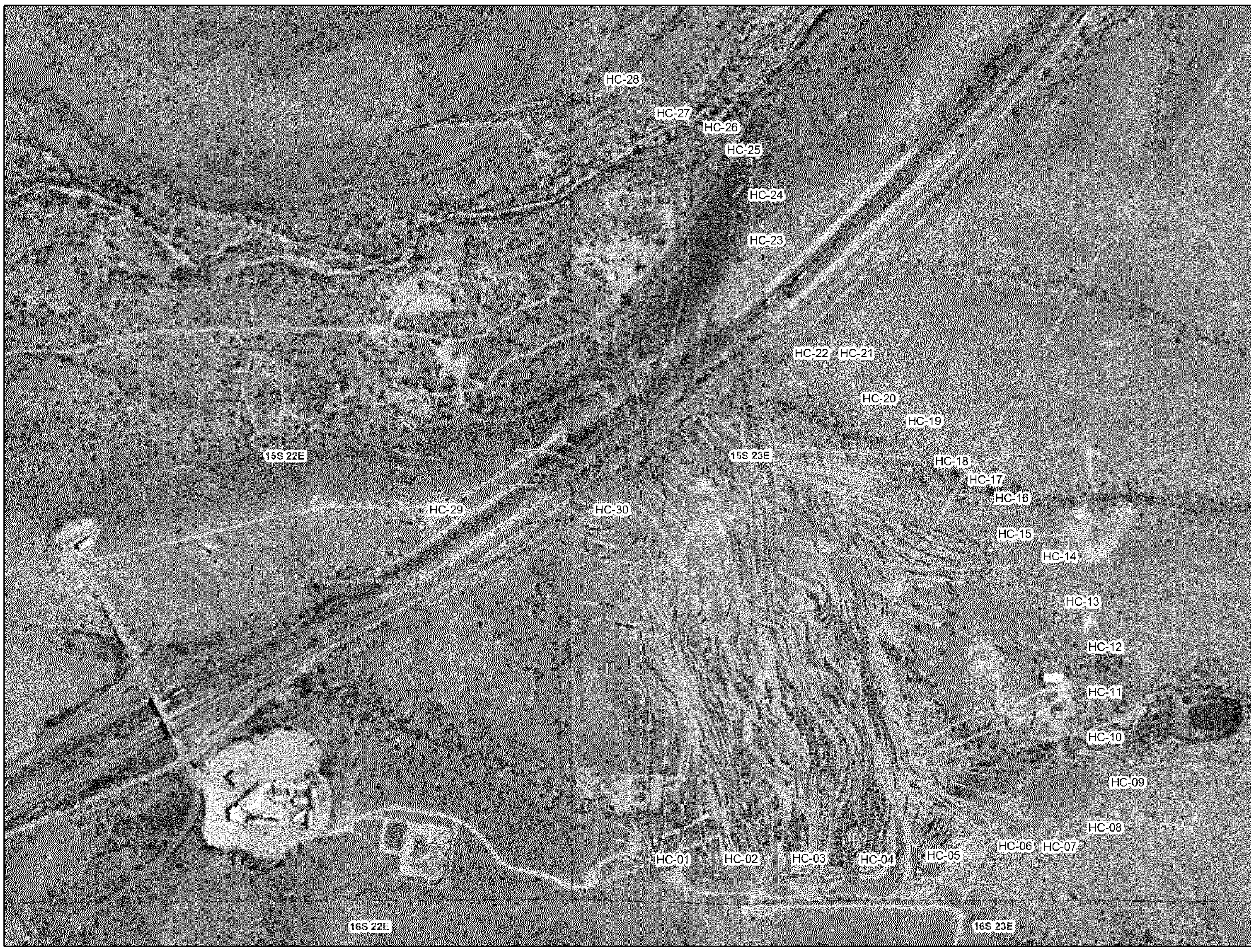
0 200 400 800
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
March 2017

Date	File ID
3/21/17	373002

CLEAR CREEK ASSOCIATES

FIGURE 58
Updated Particle Tracks for Layer 4



Explanation

Particle Tracks for Layer 5

YEAR

- 1 - 3
- 4 - 6
- 7 - 9
- 10 - 12
- 13 - 15
- 16 - 18
- 19 - 21
- 22 - 23

Hydraulic Control Wells

Wellfield

Township

Particles started outside the wellfield area to the west were deleted until they entered the area of the wellfield.

0 200 400 800
Feet

Excelsior Mining Arizona, Inc.
Groundwater Flow Model
Gunnison Copper Project
March 2017

Date	File ID
3/21/17	373002

CLEAR CREEK ASSOCIATES

FIGURE 59
Updated Particle Tracks
for Layer 5